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Education with the Lunar Theme

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Education with the Lunar Theme

An Interactive Qualifying Project Report:
Submitted to the faculty of the
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science
By:

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Approved:

Prof. Antony G. Dixon, Advisor

This report represents the work of three WPI undergraduate students, submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review.

Abstract

Our goal was to design a project incorporating the lunar theme that could be presented to the students with minimal inconvenience to the faculty. This project made use of multiple presentations to enhance students' interests in scientific topics related to the lunar theme. It was our hope that these presentations would enrich the students' learning experience and motivate them to research these topics in their own time. Our final goal was for teachers to be able to use this project to motivate their students.

The idea from using the lunar theme came from the great appeal of space and the concept of a lunar base. Also, the scientific principles present in a lunar base can be integrated into the current science and technology topics outlined in the Massachusetts curriculum for middle school students. The presentations that comprised this project reflected these topics.

The process for this consisted of brainstorming multiple concepts for the short presentations that would be informative, interesting, and simple to do. We then moved to a selection and testing process to determine our final choices to be presented. Finally, the presentations were able to be performed in a middle school science class. The general perspective gained from the teacher and students were favorable, however the analysis of these reactions could be streamlined in future endeavors.

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Problem Statement

The eighth grade science curriculum for 12-year olds in Worcester Public Schools covers five main areas. Namely, Earth Science, Life Science, Physical Science, Technology/ Engineering, and Design as seen in the Massachusetts Science and Technology/ Engineering Framework (see Appendix). Each of these areas is broad and requires more time to be spent on it than the 45-minutes of class time already allotted to it. Given the amount of material to be covered, it soon becomes a monotone experience for the middle school students as they are bombarded with information class after class in order to meet deadlines to cover these materials.

The eighth grade class we observed was not an exception in this regard, as each class period was only about 45 minutes; a time we do not think is sufficient for the students to absorb, retain and analyze new concepts and material unless it is presented in an engaging manner that lets the students visualize the material, analyze it and become actively involved. True, homework is given and class exercises such as recitations and simple experiments are organized by the teachers in a bid to stir up and appeal to the studentsô sense of involvement. But these are simply not enough as they pose little challenge and become just class routines to the students, who more often than not, participate in them solely for the purpose of getting good grades and moving to the next class.

Fully aware of these limitations, some middle-school teachers do what they can to help

and some have developed a few ways to overcome this hurdle. One such teacher from Forest Grove Middle School here in Worcester is Mr. Donald Brown, the eighth grade science teacher we worked with over the course of this project. He has on display in his class, a dinosaur skull which he owns personally. He also has had robotics projects where the students made rover vehicles. One of these rovers, in construction at the time of our project, was designed to pick objects up and lift them to a certain height. This, in regard to the purpose of our project which deals with using the concept of the lunar-base to spark interest in middle school science students, was very appropriate because it could be used to illustrate part of a simple process of mineral extraction on the moon, taking into account the influences gravity has on basic principles of mechanics.

Moreover, Mr. Brown was very willing to let us test any of our motivation strategies and techniques on his students, believing that this would be to their benefit in one way or another, or at least increase motivation towards scientific concepts. Most middle school teachers stick to the curriculum, to what would work in the little time available to them for planning and instruction and to what they can afford with the inadequate funding they have for materials (Hoostein 1994). The greater of the aforementioned problems is the lack of time for planning, instruction and enriching activities allowed by the classroom time limits presented by the schedule.

Project Statement

Among the courses that make up the Physical Science and the Life Science categories within the eighth grade curriculum (biology, chemistry and physics), there is little room for using interdisciplinary themes to spark interest in the students. Therefore our goal was to raise student interest in these science courses by connecting certain topics to the concept of a proposed lunar base.

We found the lunar base concept to be an appropriate interdisciplinary theme for this project because many basic science concepts would apply to a base on the moon. Biology would explore the possibility of living on the moon and ways of sustaining humans, animals and plants. Chemistry would discuss the extraction of minerals on the moon such as platinum, chromium and helium-3. Physics would include heat transfer, differences in gravitational pull, simple propulsion systems, and the influences of the lunar environment on basic mechanical principles. Anatomy and physiology would explore the effects of exposure to solar radiation and the effects the moonôs lower gravitational pull has on the human body, such as decreased bone density and muscle fatigue. All these topics are critical in understanding how a base on the moon would work and would act as good motivation for the students.

We decided to link the lunar-base theme to classroom studies by designing and having the students carry out experiments and classroom activities that are relevant to a proposed lunar base but also demonstrate certain scientific concepts. We intended to achieve this by bringing students into contact with basic processes involved in getting to the moon, surviving there as well as navigating the lunar terrain.

Our confidence in the lunar-base theme came from previous Interdisciplinary Qualifying Projects. First it was the fact that there have been at least two IQPs in recent years based on the lunar theme as it relates to middle schools here in Worcester. And each of these projects was quite successful. The first one, titled ñThe Educational Case for a Simulated Lunar Baseò concluded that they enjoyed positive reactions from students in 4th and 6^{th} grade and from this were encouraged that their project could eventually building up to ñsomething impressive over the next 5 years.ò The second, titled ñDeveloping a Fifth Grade Lunar-Themed Science Curriculum Unit,ò even reported an overcrowding issue as a result of ñthe massive interest shown by Worcester schools.ò As a group, we felt the lunar theme would help the middle school students appreciate our planet, Earth, more by making them aware of its place in the solar system and the difficulties involved in surviving elsewhere.

Background and Related Works

Our greatest resources were the collection of prior work on the subject of student motivation as well as previous IQP projects on the lunar-theme as it relates to pre-college student instruction. Such previous projects were ñHarnessing He-3 on the Moonò, ñSustaining Agriculture on the Moonò, ñThe Educational Case for a Simulated Lunar Baseò, ñThe New Space Race Initiativeò and most importantly ñDeveloping a Fifth Grade Lunar-Themed Science Curriculum Unit.ò We browsed through these projects to gather information that might be relevant to our project.

Out of these previous projects, the one most relevant to ours was the project ñDeveloping a Fifth Grade Lunar-Themed Science Curriculum Unit.ò This and a research article about a study on student motivation titled ñMotivating Students to Learnò became the basic background materials we worked within our project.

However, as we went over previous projects, we found that the project ñThe Educational Case for a Lunar Baseò was also very helpful as it enabled us to see and be convinced about the educational value of the lunar base theme. We discovered this would be the starting point if we would use the lunar base theme in any way to motivate academic interest in science.

Furthermore, Professor John Wilkes, Associate Professor in the WPI Social Sciences and Policy Studies department was an invaluable resource as he had advised most of the previously mentioned IQPôs and through this had developed a good relationship with middle schools in the area as well as their teachers. One such teacher was Mr. Brown who was introduced to us by Professor Wilkes and who let us use his 8^{th} grade class at Forest Grove middle school to test our strategies and techniques.

The research reported in the article ñMotivating Students to Learnò tried to identify the strategies that middle-school social studies teachers at the 8^{th} grade level use to motivate students to learn U.S. history. The purpose for this study was to explore why teachers used certain strategies. This was done in order to understand teachersô theories of motivation, since these theories guide teachersô classroom practices.

The strategies identified were simulations or role-playing activities, projects that involved the creation of products such as videos and dioramas, relating history to current events in studentsô lives, assigning students to read historical novels, using thought provoking questions, inviting guest speakers from the community, showing videos and films, organizing cooperative learning activities, and providing small-scale hands-on experiences. In general, teachers sought to use strategies that would accomplish lesson objectives in more interesting, engaging and relevant ways by appealing to studentsô interests through novelty, questioning, variety and active participation.

A striking observation from the list of motivational strategies identified by teachers was that these strategies were not based on conventional patterns of social studies instruction which are comprised of textbook-based, large-group, teacher-controlled recitation and lecture. Rather, it appeared that teachers used motivational strategies to supplement conventional instruction.

The study also demonstrated the importance of feedback from the subject-matter, namely, the students; since prior research on student motivation had often failed to seek studentsô opinions on the motivational strategies and methods employed by their teachers. This study, therefore gave students the opportunity to identify the strategies that actually motivated them from the list of motivational strategies used by their teachers. Successful strategies were those responsive to the studentsô needs, values goals and experiences. These included role-playing characters in simulations, class discussions, acting in dramatic presentations and watching videos or films.

Students expressed their desire to have a sense of control over the content of their topics in the classroom. They wanted to choose what they would learn. This is compatible with what researchers have found: that middle-school students (12 to 14 year-olds), or students of that age range need a more personal, student-managed environment that encourages freedom of choice and a sense of control over learning activities.

Finally, the study identified the factors that prevent teachers from successfully motivating students. Identifying these restrictions would make it possible for them to be removed so that teachers can concentrate on factors that are under their control. There were 3 major categories of constraints identified by the teachers, namely, school factors, student factors and parental factors. The teacherõs primary problem factors pertained to difficulties with the school rather than with students or parents. These included insufficient planning, instruction time and inadequate funding for materials and resources. Hence our attempt to come up with simple and cost efficient experiments that can be done in manageable time.

This research article was very important to this project as it provided useful information from a study similar to ours. We were able to identify and analyze the methods and strategies employed by middle school teachers to motivate their students, the motivation behind these methods, why these methods worked or didnõt work and the general factors that make it difficult for teachers to motivate students to learn. By exploring all these we were able to come up with simple activities that would help students to visualize, analyze and become actively involved, all within the limited time designated for a class period.

Proposed Demonstrations

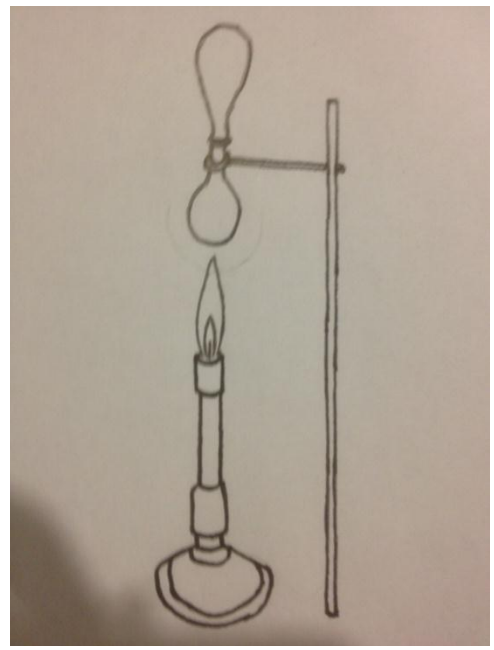
Using the subjects covered by the eighth grade curriculum as a basis, we began brainstorming varies activities that related the curriculum to the projectôs Lunar theme. The goal of this was to come up with as many ideas as possible and then choose the ones that we felt conveyed our message most efficiently.

One activity that was suggested was to use a hot plate to demonstrate the different methods of heat transfer. In order to demonstrate the process of conduction, the transfer of heat between objects, a beaker and ice cubes would be needed in addition to the hot plate. The beaker would be placed on the hot plate and filled with ice cubes. The hot plate was then turned on. The ice cubes would begin to melt as the hot plate heated up and transferred heat to the beaker, which in turn transferred heat to the ice cubes.

The second thermal activity suggested dealt with convection, the transfer of heat through the motion of a fluid. This activity required two beakers and food coloring along with the hot plate. The two beakers were filled with water. One beaker was placed on the hot plate and the other was placed on the table. The hot plate was then turned on. As the water was heating, the food coloring was added to both beakers. The food coloring in the beaker on the hot plate should move upwards, towards the surface of the water and then fall back down to the bottom. The food coloring was following the flow of the water as convection occurred.

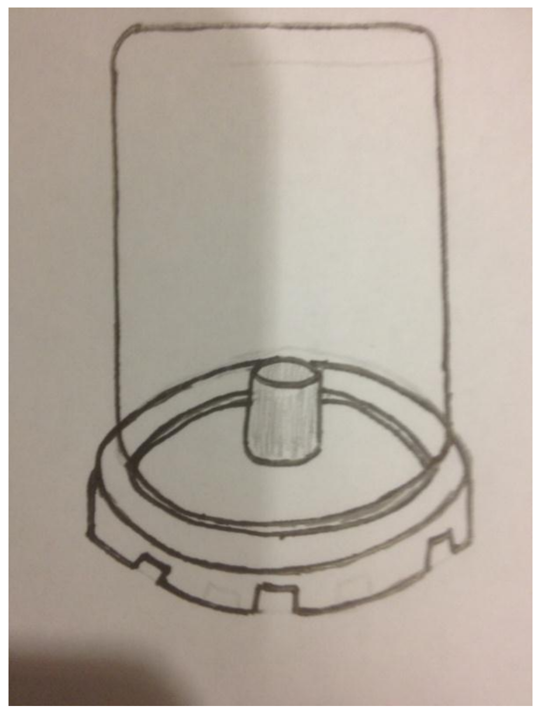
The third thermal activity suggested involved thermal radiation. This activity would aim to illustrate how the sun had to be taken into account when a person goes beyond the protection of the Earthôs atmosphere. In this activity a dish was suspended from a clamp and an ice cube was placed on it. The hot plate was placed in such a way that it was not directly under the dish but the heating surface was facing it. The hot plate was then turned on and the ice cube was observed. The ice cube would melt at a faster rate than before the hot plate was turned on. Since the dish and ice are not in direct contact with the hot plate, heat is not transferred by conduction. Hot air always rises upwards, not sideways or downwards, therefore heat is not transferred by convection.

Another of the suggested activities involved thermal energy and expansion of gas. This experiment was meant to demonstrate how gas and heat interact during the launch of a rocket. In this experiment a bottle would be placed over a Bunsen burner. A balloon was placed over the mouth of the flask and the Bunsen burner was turned on. After a certain amount of time, the balloon would begin to expand. With the mouth of the bottle covered by the balloon, no air could enter the bottle to cause the balloon to inflate. The fact that it did inflate, however, would show that gas expand when heated.



The last activity that dealt with thermal energy that was suggested was a demonstration of how heat is lost in the process fluid cooling of a heated object. The concepts of fluid cooling could be applied to how the heat produced by the functions of the shuttle was regulated. This demonstration involved a hot plate, 2 cups, cold water, a funnel, a small hose, 2 thermometers and a metal object, such as a paperclip, to be hung from the end of the hose. Before the demonstration, the thermometers were used to measure how long it took the water and clip to reach room temperature after being heated. This was to illustrate that the temperature changes in the experiment were due to the water-object interaction. After the measurements had been taken, one of the cups was filled with cold water and the metal object was heated. The funnel was fit onto the hose. The temperature of the water and object were measured. The cold water was poured into the funnel, down the hose, and into the second cup, causing the water to run over the metal object. The temperatures of the metal object and the water were taken again. This demonstration showed the process of conduction in action and demonstrated a practical method of cooling.

One of the suggested activities dealt with why it was important to isolate supplies and the living environment of a space shuttle and Lunar base from the vacuum of space. This activity required a cup of water, a marshmallow, and a vacuum chamber. The marshmallow and cup of water would both be placed in the vacuum chamber at different times. The pressure in the chamber would then be reduced and the result would be observed. The marshmallow would expand and the water would begin to boil. This was to show how the internal pressure of an object reacts to a vacuum and how matter can change states without the addition of thermal energy.

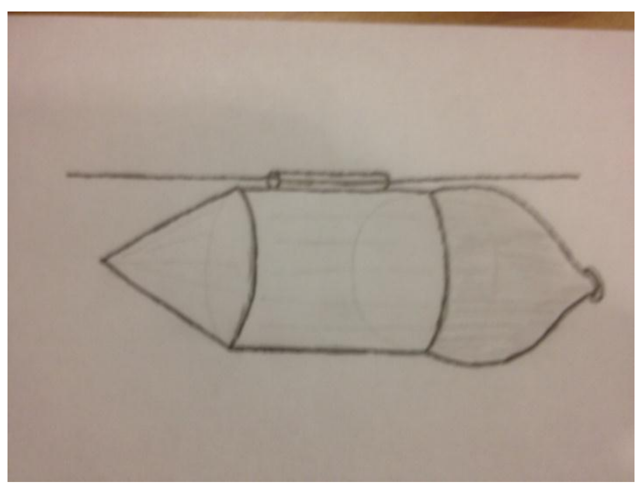


An important aspect of a lunar base is why it would be economically feasible to build one. To demonstrate this, several activities were proposed that demonstrated how the lunar soil, or regolith, could be harvested and utilized. One of these activities involved sand, iron fillings, and a bar magnet. The iron fillings were mixed into the sand, simulating the lunar regolith. One end of the bar magnet was then used to stir the mixture. The bar magnet would then be removed from the mixture, covered in the iron fillings.

Another example of how certain useful materials could be gathered was to boil saltwater to separate the salt and water. The beaker filled with salt water would be placed on a tripod over a Bunsen burner. The saltwater would be heated until all of the water had evaporated, leaving the salt behind. These activities would demonstrate how iron and other useful materials could be gathered from the lunar environment instead of needing to be shipped there; dramatically reducing the cost in fuel it would take to build a lunar base.

One of the major aspects of the target curriculum was the chemistry requirement. With this in mind, one of the suggested activities was to dissolve Styrofoam in acetone to demonstrate a chemical reaction. This concept could be used to demonstrate the forces behind a rocket launch. First, the acetone, which can be found in nail polish, was poured into a bowl. The Styrofoam would then be added to the bowl and the reaction would be observed.

To demonstrate how the lunar team would get to the moon, one of the suggested activities was to build simple model rockets. These rockets would be made from string, straws, tape and balloons. The straw would be cut to a specific length and taped to the balloon. The string would then be fed threw the straw. One end of the string was then attached to a stationary object. The balloon and straw were held at the opposite end of the string and inflated. The balloon was then



released and the ñrocketò would be sent down the string. This experiment could then be repeated with the balloon being inflated to different sizes. The purpose of this was to demonstrate how many different factors go in to a successful flight to the moon.

Inspired by the balloon and string rocket, it was suggested to try to use the same concept to model a multistage rocket. The process was much the same with the exception of two important steps. First, a second piece of straw was added in front of the rocket to simulate the capsule. Second, a second piece of string was tied to the end of the rocket so that it only went a certain distance and then stopped. The capsule would then keep going, showing how, in the absence of a noticeable gravitational field or atmospheric friction, inertia allows a spacecraft to keep moving without having the engines at a constant burn

The third rocketry activity that was proposed was to use pressurized water bottle rockets. This experiment required two-liter bottles, and air pump and stand, and material to make the nose and wings out of. The rocket would be designed and built by the students. The rocket would then be loaded onto the stand and pressurized. It could then be launched and the flight observed. Like the balloon and harness experiment this activity would address how the astronauts would get to and from the lunar base. This activity was to demonstrate the concepts of basic rocketry and the concept of momentum versus gravity during flight.

One of the suggested activities dealt with how the lunar team would return to Earth safely. To demonstrate this concept an egg drop was suggested. The egg would represent the crew and the students would have to design a capsule to protect it. The capsule designs would then be dropped out a window into a large tub of water. A control capsule, without any safety features, would also be dropped. The results of both drops would then be compared to emphasize the importance of safety measures in a successful return trip to Earth.

Gravity and inertia were two of the most important topics of the target age groupȏs curriculum. These topics would also be important in the lunar base. One situation in which the topic of gravity would be very important would be in how the difference in gravity on the moon would affect the structural requirements of the lunar base. One activity that was suggested to demonstrate this was to drop a basketball and golf ball at the same time from the same height and observe their fall. Regardless of the height from which the balls were dropped, so long as they were dropped from the same height, they will hit the ground at the same time. This activity shows that the force of gravity acts uniformly on all things, regardless of the objectsô mass.

In order to address the topic of inertia, it was suggested to do an activity where a bucket of water was spun from a piece of rope. As the bucket was spun, the rope would be cut and the bucket would go flying. This activity showed that without the rope keeping it in a circular motion, the bucket would move in a straight line, following the path of its inertia. This is similar to how the gravitational pull of the sun and the inertial moment of the planets interact to form the planetôs orbits. Also, the fact that the water remained in the bucket as it was spun was an example of centrifugal force in motion. The force exerted on the water by the spinning of the bucket would cause it to stay in the bucket regardless of the bucketôs position. This concept could be used in Space Stations to create artificial gravity.

An important aspect of space flight is radio communication and the inevitable time delays experienced as people get further and further away. This canôt be observed on Earth very easily due to the comparatively short distances involved versus the incredible speed of the radio waves used in communication. It was suggested to drop a pebble into a pan of water to simulate the time it would take for radio waves to travel from the Earth to the Moon. The ripples produced from the pebble entering the water represented the radio waves sent from Earth. The amount of time it took the ripples to travel from one point to another demonstrated how the radio waves take time to travel.

In order to build a lunar base, robots will be needed to handle the majority of the construction. One choice to make in how to control the robots is if they should be controlled from the Earth or the Moon. If they are controlled from the Moon the Lunar base would have to incorporate structures for human inhabitance, which would be costly. However, if they were controlled from the Earth there would be a time delay that would make controlling the robots difficult. In order to demonstrate the difficulty presented by controlling the robots from the Earth, it was suggested to take two volunteers from the class. One would be blindfolded and given the controller of a remote controlled car. The second volunteer would then give the first directions. This would demonstrate the difficulties presented when you donœt have direct access to something that you are trying to control.

Consolidation

Due to the fact that there was only a limited amount of time to prepare for and present the project, not all of the proposed demonstrations could be done. As such, it was decided to cut down on the number of demonstrations that would be presented and focus on the remaining ones. We looked at each demonstration with specific criteria in mind; was it relevant to the project, could it be done in a reasonable amount of time, was it possible to do in the area provided, how much would it cost?

It was decided there only needed to be one thermal demonstration dealing with the modes of heat transfer. After reviewing the activities it was decided that the activity involving thermal radiation would be kept. It was determined that the activities involving conduction and convection werenôt as relevant to the topic of a lunar base. This was because space is a vacuum. In a vacuum there is no material through which conduction and convection can occur. Thermal radiation, however, travels as light and therefore can act in a vacuum. However, it was decided that the demonstration needed to be redesigned to make it better illustrate the point.

The next activity to be cut was the bottle and balloon demonstration of the expansion of gas. When considering what demonstrations to do we looked for ones that would engage the audienceôs interest. Watching a balloon slowly expand as the bottle was heated was determined to not be engaging enough to attract the audienceôs attention.

The demonstration that dealt with the fluid cooling of a heated object was also cut from the project. The amount of time and effort needed to implement the demonstration was determined to be impractical for the limited amount of time we had. Also, the matter of how relevant this demonstration was to the project as a whole led to it being dropped.

It was also decided to drop the demonstration dealing with the vacuum chamber, marshmallow, and cup of water. Although the topic of the demonstration was relevant to the project, acquiring the vacuum chamber made it impossible. We were unable to find one to borrow and all the ones that we looked at buying were well outside of our price range.

The activities involving separating iron from sand and salt from water were also dropped. It was decided that these demonstrations were redundant and uninteresting. We would have had the class mix the iron and sand and salt and water only to have them separated again.

It was determined that the dissolving Styrofoam activity was unnecessary. Observing how two chemicals could be combined wouldn’t have shown how hard it can be to separate two chemically bonded elements. The comparison between dissolving Styrofoam and the launch of a rocket was too much of a stretch.

The activity with the string and straw rockets was kept in the project. However, the activity of using the same concept to construct a multistage rocket was dropped. The activity was too complicated to present as a challenge to the class. Also, we didn’t want to have what was essentially two of the same activities in the same presentation.

The bottle rocket activity was also dropped, for several reasons. The first was space. We wanted to do the presentation in a classroom or gym and the rocket launches wouldn’t be possible indoors. The second was safety. We didn’t want to risk potentially hurting someone with one of the rockets. The third was that we weren’t sure how to design or build the launching platform.

The egg drop activity was cut for similar reasons to the bottle rocket activity. We wanted the presentation to be done indoors and we didn't want to risk accidently dropping one of the capsules on someone.

The basketball and golf ball drop was removed due to it being too simple. Anyone could go out and do the same thing at home and get the same effect. We wanted the project to be more unique than that.

The bucket spinning demonstration was dropped for similar reasons to the egg drop, bottle rockets, and basketball and golf ball drop. We wanted to do the project inside and the risk of hitting someone when the bucket went flying was too high. Also, anyone could fill a bucket with water and swing it around and achieve the same effect.

The radio waves and ripples comparison demonstration was cut from the project as well. We didn't think that the comparison to a group that had just learned the concept of light traveling as waves would be very clear. Also, like the bucket spinning and basketball and golf ball drop, this activity was too simple.

After dropping the above activities, we were left with three ideas. These ideas were the radiation demonstration, the balloon and harness activity, and the remote controlled robot activity. The radiation demonstration was the thermal energy demonstration that was best suited to an outer-space example. Although the balloon and harness activity was simple, it allows the students to do a hands-on activity during the presentation and experience what it is like to make a design as a group. The remote controlled robot would allow us to introduce the idea of how robots could be used to complete tasks and why it would be much easier to control them from the moon. All of these experiments were cheap and could be completed in a reasonable amount of time.

Testing

The three demonstrations that were chosen to be part of the final presentation were the thermal radiation demonstration, the straw and balloon demonstration, and the remote controlled robot demonstration. With the ideas in place, these activities needed to be tested to ensure that they worked as intended, and if they didn't, to find what needed to be changed.

The first activity to be tested was the straw and balloon rocket. The string was set up and the balloon was taped directly to the straw and released. Due to the stretching of the balloon as it deflated, the tape couldn't stay attached once it had deflated completely. This meant that in order to repeat the experiment, the entire thing had to be set up from stage one each time.

To account for the balloons stretching, it was decided to make a harness that the straw would be taped to and the balloon would be placed inside. This would make repeated launches much easier. The first harness design was half of a 2-liter bottle. However, the bottle was too heavy for the balloon to move. By cutting away portions of the bottle we saw that the harness moved slightly further. In order to further lighten the weight of the harness a new one was built out of paper. The paper harness worked as intended. With it, it was determined that the orientation of the balloon, how well the straw lined up with the string and how tightly the string was pulled were all factors in how far the harness went. With the inclusion of the paper harness, it was decided that they main focus of this activity would be to have the class design their own rockets.

The second activity to be tested was the thermal radiation demonstration. It was decided that the original demonstration was too indirect in demonstrating how heat is transferred through light. In order to better demonstrate thermal radiation the hot plate was replaced by a heat lamp. The main focus of this activity was changed to how the astronauts would be protected from the thermal radiation given off by the sun. An astronautsô suit is covered by a material called Mylar, which is visually similar to aluminum foil. Using a thermometer two readings were then taken from the heat lamp; one with just the lamp and one with the aluminum foil covering the lamp. We found that the aluminum foil performed as intended and blocked the heat that was being produced by the heat lamp. We also found that it was more efficient to take the measuring with the aluminum foil first due to how long it can take the thermometer to return to room temperature.

The last demonstration to be tested was the remote controlled robot activity. We wanted this activity to be more technical than the other two. As such, we decided to try to use a time delay to simulate the delay experienced from the Earth to the Moon. In order to create the time delay a microphone, speakers, and a laptop were used. The idea was to have one student in the room with the robot giving commands to another student out in the hall over the microphone. The microphone would be connected to the laptop which would run the recorded audio signal through a real-time audio signal time delay program. The resulting signal would then be sent to the speakers which were with the student with the remote control, who would be out on the hall. However, due to technical difficulties we were unable to implement and test this activity. In the end we decided that having the student controlling the robot face away from it while another student relayed instructions was enough to illustrate the difficulties of not having direct access to something that you are trying to control.

Presentation

The presentation itself was supplemented with a basic Microsoft Powerpoint file making use of a few slides featuring the theme of the project, the relevant topics covered, and pictures used to help illustrate what the topics applied to. This presentation was to be used in conjunction with a short verbal presentation in which we would introduce ourselves and explain the relevant topics at hand. A shorter introduction would be given at the beginning of each experiment to explain the general concept behind the activities. These introductions were to be about three to four minutes long, covering the importance and background of the scientific topics to be covered by the demonstration to follow.

After the introduction, we began with the demonstration dealing with heat transfer by radiation. One group member gave the verbal presentation, another set it up, and the last stood by and recorded the reactions of the class. As the presenter explained why it is important for an astronaut to be protected from thermal radiation, another member placed aluminum foil over a heat lamp. The class was told to gather around the demonstration area, and the experiment began. The dangers presented by the heat of the lamp were brought to the attention of the class. Despite this, a few students got too close to the lamp, but these were minor cases. As the presenter explained the concept behind the demonstration, the students would be allowed to place their hands in front of the heat lamp. The presenter would then use a thermometer to show that there was very little, if any, heat being given off by the heat lamp. The aluminum foil would then be removed. The students would again be given the chance to place their hands in front of the heat lamp in order to experience the difference in heat given off by the shielded and unshielded heat lamp. The students expressed great interest in how drastic a change in temperature removing the tin foil caused.

Continuing off of the enthusiasm from the experiment, the presenting group member then went on to a closing piece for the experiment. He asked questions that detailed why radiation shielding is needed to survive on the moon and elsewhere in space. He also continued onto the real world example of the use of Mylar and gave information on spacesuits in current use by space agencies now.

The next topic that was covered was communications technology. We switched our roles of presenter, documenter, and helper as well. The group member presenting this topic moved into the experiment quickly, the goal of this to being to get the class to ask how this experiment was relevant. Two volunteers were chosen from the class. One of the students was given a remote control and turned so that they couldnǿt see the robot. The second student then relayed directions to the first. The RC car that was brought quickly became a handicap as it was too fast and difficult to control. Luckily, Mr. Brown had a much slower and easier to control robot that was able to make this happen. As the two students were working together, the presenter continued on about the importance of the demonstration to the topic, citing the difficulty radio delays from the Earth to the moon can cause. The hands-on nature of the demonstration was engaging for most of the class and several observers began shouting out directions. Once a lap around the center table had been achieved, the presentation moved to the next topic.

The final topic for the class was the lunar transportation demonstration. We again switched roles so every one of us had an opportunity at each position. This presentation followed a more traditional method of giving background before the activity. In this activity the students used paper, balloons, tape and string to design, build, and launch simple model rockets. This experiment would encourage the students to consider the different aspects of the rocket design that need to be considered, such as how much material can I take out before running the risk of the balloon ripping the harness apart? As the project was organized, the class was separated into groups and each group designed a rocket. Equal lengths of string would then be cut for each group. One end of the strings must be anchored to a stationary object. It doesnąt have to be the same object, so long as all the strings are anchored at the same height. The groups of students are then given time to collaborate, brainstorm, and build the rocket. Each group then tests their rocket three times. With each launch the group is given a chance to redesign their rocket. The longest launch is then recorded for each group. This experiment emphasizes the amount of work that goes into designing and building a rocket as well as some of the factors that must be accounted for when a rocket is launched, such as the amount of fuel, the size and shape of the rocket and the alignment of the rocket during launch. There was one student who was hesitant to join a group and so we had the person in question join a smaller one. We were pressed for time and as a result, could not fully complete this experiment.

Analysis

The reactions from the classes were generally positive in light of the activities as a whole. Interactions that made use of the whole class kept general interest up, and allowed the presenter to stress the implications for these sciences to what they apply to on a lunar base. Comments from the teacher were positive as well, especially being surprised by how effective yet simple the presentations were.

The students were very enthusiastic for the heat transfer experiment. Having them all gather around the experiment area and allowing them to feel the illuminated area themselves was a great hands on experience to them. Most of the students were also quite surprised at the results for just how effective the tin foil was. This can be a good learning experience to understand how the science physically works. The students' levels of enthusiasm and engagement were encouraging signs of their motivation toward and interest in scientific topics. The emphasis on Mylar and presenting our lunar theme helped lead this motivation toward our goal, but could not be immediately determined. However, this does not mean we were entirely successful. This experiment was well received by both the teacher and students alike, and it seems like a great short experiment to run in any science class.

The enthusiasm carried over to the second experiment, likely riding on the success of the last. The technique of heading directly into the action and then expanding on the topic during the experiment, kept the excitement high. Just the prospect of using the RC car in class was a large boon to interest. Once a controllable vehicle was in use, the challenge brought the entire class into the action. This experiment presented difficulties in controlling the entire class, and as a result was not entirely successful in drawing the correct conclusions. The students were having fun, but it did not seem like the push toward the lunar theme was quite making it to them. Mr. Brown was still interested in this experiment, however. Integrating most of the exposition into the action was also a success in making economical use of time, but did still carry the earlier stated disadvantage of losing the class's focus.

For the last experiment, the concept of splitting up into groups resulted in a flurry of activity and enthusiasm from the class. After viewing a demonstration of the completed experiment caused a great amount of excitement in the entire class. The opportunity to create and implement their own designs was very exciting. Many students had questions about how we had designed our own rocket as well as advice for their own designs. When the period was coming to an end, many students still wanted to finish their rockets. One student even stayed a little late in order to have the chance to launch her groupôs rocket.

Criticisms of our presentations revolved mostly around speaking time. By keeping the presentation moving interest in the topic at hand remains high. Having the discussions shorter and more to the point can help this as well as allow more time for the next experiments. More experience would be needed to identify and fix common questions and issues. Inexperience in public speaking was also a disadvantage for our group, as there were many slips, pauses, and stalls before bringing up the next topic.

These suggestions and alternative methods for the improvement of the process as a whole are to make the concept more accessible as well as more streamlined. One suggestion would be to give these ideas for experiments to science teachers and having them demonstrate these concepts at appropriate times for their curriculum. Unfortunately, we cannot reliably present the lunar theme if the concepts were outsourced. Having more experience in the field of public speaking can also bring about an advantage to how to read and control a situation as well as streamline it. Although initially thought to eliminate motivation for learning, providing a survey to the students and teachers can not only give helpful suggestions and insights on our own performance, but also help further present the lunar theme.

Conclusion

The primary goal of our project was to increase student interest in scientific topics related to the lunar theme. To accomplish this, we developed short and engaging presentations that would introduce them to the scientific concepts behind a lunar base. These presentations were meant to give the students hands on experience with the intended topics. We came to the conclusion that three presentations would be ideal for our goals. These presentations included one on thermal radiation, one on communications and time delays, and one on rocket propulsion and design.

The presentations were selected from a number of suggested ideas that were narrowed down based on the constraints that were determined for our project. The primary constraints were the price for the materials, how long each presentation took, and the relevance of the presentations. The remaining presentations were then tested and altered to better fit their intended purpose.

We then presented our project in Mr. Brownộs science class at Forest Grove Middle School. We felt that our presentations had a positive impact on the participating students. However, the methods we used could have been improved for both the presentation itself as well as gathering data. It would also have been a good idea to be mindful of the analytical perspective during the entire process. One way to do this would have been to include a survey for the students to fill out after the presentation.

Appendix A

Earth and Space Science

In earth and space science, students study the origin, structure, and physical phenomena of the earth and the universe. Earth and space science studies include concepts in geology, meteorology, oceanography, and astronomy. These studies integrate previously or simultaneously gained understandings in physical and life science with the physical environment. Through the study of earth and space, students learn about the nature and interactions of oceans and the atmosphere, and of earth processes, including plate tectonics, changes in topography over time, and the place of the earth in the universe.

Å In **grades 6–8**, students gain sophistication and experience in using models, satellite images, and maps to represent and interpret processes and features. In the early part of this grade span, students continue to investigate geological materialsô properties and methods of origin. As their experiments become more quantitative, students should begin to recognize that many of the earthôs natural events occur because of processes such as heat transfer.

Students in these grades should recognize the interacting nature of the earthôs four major systems: the geosphere, hydrosphere, atmosphere, and biosphere. They should begin to see how the earthôs movement affects both the living and nonliving components of the world. Attention shifts from the properties of particular objects toward an understanding of the place of the earth in the solar system and changes in the earthôs composition and topography over time. Middle school students grapple with the importance and methods of obtaining direct and indirect evidence to support current thinking. They recognize that new technologies and observations change our explanations about how things in the natural world behave.

Learning standards for grades 6ï 8 fall under the following five subtopics: *Mapping the Earth; Earth's Structure; Heat Transfer in the Earth System; Earth's History;* and *The Earth in the Solar System.*

Earth and Space Science learning standards are also grouped under Broad Topics in Appendix I, which highlights the relationships of standards among grade spans.

Earth and Space Science, Grades 6–8

LEARNING STANDARD	IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES
Mapping the Earth	
1. Recognize, interpret, and be able to create models of the earth's common physical features in various mapping representations, including contour maps.	Choose a small area of unpaved, sloping ground in the schoolyard or a park. Create a scale contour map of the area. Include true north and magnetic north.
Earth's Structure	
2. Describe the layers of the earth, including the lithosphere, the hot convecting mantle, and the dense metallic core.	Use a Styrofoam ball and paint to construct a cross-section model of the earth.
Heat Transfer in the Earth System	
3. Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through the earth's system.	Investigate the movement of a drop of food coloring placed in water, with and without a heat source, and in different positions relative to a heat source.
4. Explain the relationship among the energy provided by the sun, the global patterns of atmospheric movement, and the temperature differences among water, land, and atmosphere.	Note the relationship between global wind patterns and ocean current patterns.
Earth's History	
5. Describe how the movement of the earth's crustal plates causes both slow changes in the earth's surface (e.g., formation of mountains and ocean basins) and rapid ones (e.g., volcanic eruptions and earthquakes).	ÅUse the Pangaea map to understand plate movement. ÅResearch and map the location of volcanic or earthquake activity. Relate these locations to the locations of the earthôs tectonic plates.
6. Describe and give examples of ways in which the earth's surface is built up and torn down by natural processes, including deposition of sediments, rock formation, erosion, and weathering.	ÅObserve signs of erosion and weathering in local habitats and note seasonal changes. ÅVisit local sites following storm events and observe changes.

Earth and Space Science, Grades 6–8

LEARNING STANDARD	IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES
Earth's History (cont.)	
7. Explain and give examples of how physical evidence, such as fossils and surface features of glaciation, supports theories that the earth has evolved over geologic time.	Make a timeline showing index fossils. Discuss which of these fossils are actually found in New England. Discuss why some may be missing from local rocks.
The Earth in the Solar System	
8. Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motions.	Observe the speed at which objects of various mass drop from a common height. Use a chronometer to accurately measure time and plot the data as mass versus time necessary to reach the ground.
9. Describe lunar and solar eclipses, the observed moon phases, and tides. Relate them to the relative positions of the earth, moon, and sun.	Use globes and a light source to explain why high tides on two successive mornings are typically about 25 hours (rather than 24) apart.
10. Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).	Using light objects such as balloons or basketballs, and heavy objects such as rocks, make models that show how heavy a 1 kg pumpkin would seem on the surfaces of the moon, Mars, Earth, and Jupiter.
11. Explain how the tilt of the earth and its revolution around the sun result in an uneven heating of the earth, which in turn causes the seasons.	
12. Recognize that the universe contains many billions of galaxies, and that each galaxy contains many billions of stars.	Count the number of stars that can be seen with the naked eye in a small group such as the Pleiades. Repeat with low-power binoculars. Repeat again with telescope or powerful binoculars. Research the number of stars present. Discuss the meaning of the research and its results.

Life Science (Biology)

The life sciences investigate the diversity, complexity, and interconnectedness of life on earth. Students are naturally drawn to examine living things, and as they progress through the grade levels, they become capable of understanding the theories and models that scientists use to explain observations of nature. In this respect, a PreKï 12 life science curriculum mirrors the way in which the science of biology has evolved from observation to classification to theory. By high school, students learn the importance of Darwinôs theory of evolution as a framework for explaining continuity, diversity, and change over time. Students emerge from an education in the life sciences recognizing that order in natural systems arises in accord with rules that seem to govern the physical world, and can be modeled and predicted through the use of mathematics.

Å In **grades 6–8**, the emphasis changes from observation and description of individual organisms to the development of a more connected view of biological systems. Students in these grades begin to study biology at the microscopic level, without delving into the biochemistry of cells. They learn that organisms are composed of cells and that some organisms are unicellular and must therefore carry out all of the necessary processes for life within that single cell. Other organisms, including human beings, are multicellular, with cells working together. Students should observe that the cells of a multicellular organism can be physically very different from each other,

and should relate that fact to the specific role that each cell has in the organism (specialization). For example, cells of the eye or the skin or the tongue look different and do different things. Students in these grades also examine the hierarchical organization of multicellular organisms and the roles and relationships that organisms occupy in an ecosystem. As is outlined in the *National Science Education Standards*, students in grades 6ï 8 should be exposed in a general way to the systems of the human body, but are not expected to develop a detailed understanding at this grade level. They should develop the understanding that the human body has organs, each of which has a specific function of its own, and that these organs together create systems that interact with each other to maintain life.

At the macroscopic level, students focus on the interactions that occur within ecosystems. They explore the interdependence of living things, specifically the dependence of life on photosynthetic organisms such as plants, which in turn depend upon the sun as their source of energy. Students use mathematics to calculate rates of growth, derive averages and ranges, and represent data graphically to describe and interpret ecological concepts.

Learning standards for grades 6ï 8 fall under the following eight subtopics: *Classification of Organisms; Structure and Function of Cells; Systems in Living Things; Reproduction and Heredity; Evolution and Biodiversity; Living Things and Their Environment; Energy and Living Things;* and *Changes in Ecosystems Over Time.*

Life Science (Biology), Grades 6–8

LEARNING STANDARD	IDEAS FOR DEVELOPING INVESTIGATIONS AND LEARNING EXPERIENCES
Classification of Organisms	
1. Classify organisms into the currently recognized kingdoms according to characteristics that they share. Be familiar with organisms from each kingdom.	
Structure and Function of Cells	
2. Recognize that all organisms are composed of cells, and that many organisms are single-celled (unicellular), e.g., bacteria, yeast. In these single-celled organisms, one cell must carry out all of the basic functions of life.	Observe, describe, record, and compare a variety of unicellular organisms found in aquatic ecosystems.
3. Compare and contrast plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, cytoplasm, chloroplasts, mitochondria, vacuoles).	Observe a range of plant and animal cells to identify the cell wall, cell membrane, chloroplasts, vacuoles, nucleus, and cytoplasm when present.
4. Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.	
Systems in Living Things	
5. Describe the hierarchical organization of multicellular organisms from cells to tissues to organs to systems to organisms.	
6. Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.	

Life Science (Biology), Grades 6–8

Learning Standard	Ideas for Developing Investigations and Learning Experiences
Reproduction and Heredity	
7. Recognize that every organism requires a set of instructions that specifies its traits. These instructions are stored in the organism's chromosomes. Heredity is the passage of these instructions from one generation to another.	
8. Recognize that hereditary information is contained in genes located in the chromosomes of each cell. A human cell contains about 30,000 different genes on 23 different chromosomes.	
9. Compare sexual reproduction (offspring inherit half of their genes from each parent) with asexual reproduction (offspring is an identical copy of the parent's cell).	
Evolution and Biodiversity	
10. Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.	
11. Recognize that evidence drawn from geology, fossils, and comparative anatomy provides the basis of the theory of evolution.	Is the pterodactyl a flying reptile or the ancestor of birds? Discuss both possibilities based on the structural characteristics shown in pterodactyl fossils and those of modern birds and reptiles.
12. Relate the extinction of species to a mismatch of adaptation and the environment.	Relate how numerous species could not adapt to habitat destruction and overkilling by humans, e.g., woolly mammoth, passenger pigeon, great auk.
Living Things and Their Environment	
13. Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.	Study several symbiotic relationships such as oxpecker (bird) with rhinoceros (mammal). Identify specific benefits received by one or both partners.

Life Science (Biology), Grades 6–8

Learning Standard	Ideas for Developing Investigations and Learning Experiences
Energy and Living Things	
14. Explain the roles and relationships among producers, consumers, and decomposers in the process of energy transfer in a food web.	Distribute pictures of various producers, consumers, and decomposers to groups of students. Have each group organize the pictures according to the relationships among the pictured species and write a paragraph that explains the roles and relationships.
15. Explain how dead plants and animals are broken down by other living organisms and how this process contributes to the system as a whole.	Observe decomposer organisms in a compost heap on the school grounds, a compost column in a plastic bottle, or a worm bin. Use compost for starting seeds in the classroom or in a schoolyard garden.
16. Recognize that producers (plants that contain chlorophyll) use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.	Test for sugars and starch in plant leaves.
Changes in Ecosystems Over Time	
17. Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and the actions of humans. Describe how changes may be catastrophes such as volcanic eruptions or ice storms.	Study changes in an area of the schoolyard or a local ecosystem over an extended period. Students might even compare their observations to those made by students in previous years.
18. Recognize that biological evolution accounts for the diversity of species developed through gradual processes over many generations.	

Physical Sciences (Chemistry and Physics)

The physical sciences (chemistry and physics) examine the physical world around us. Using the methods of the physical sciences, students learn about the composition, structure, properties, and reactions of matter, and the relationships between matter and energy.

Students are best able to build understanding of the physical sciences through hands-on exploration of the physical world. This *Framework* encourages repeated and increasingly sophisticated experiences that help students understand properties of matter, chemical reactions, forces and motion, and energy. The links between these concrete experiences and more abstract knowledge and representations are forged gradually. Over the course of their schooling, students develop more inclusive and generalizable explanations about physical and chemical interactions.

Tools play a key role in the study of the physical world, helping students to detect physical phenomena that are beyond the range of their senses. By using well-designed instruments and computer-based technologies, students can better explore physical phenomena in ways that support greater conceptual understanding.

Â In **grades 6–8**, students still need concrete, physical-world experiences to help them develop concepts associated with motion, mass, volume, and energy. As they learn to make accurate measurements using a variety of instruments, their experiments become more quantitative and their physical models more precise. Students in these grades are able to graph one measurement in relation to another, such as temperature change over time. They may collect data by using microcomputer- or calculator- based laboratories (MBL or CBL), and can learn to make sense immediately of graphical and other abstract representations essential to scientific understanding.

Learning standards for grades 6ï 8 fall under the following five subtopics: *Properties of Matter; Elements, Compounds, and Mixtures; Motion of Objects; Forms of Energy;* and *Heat Energy.*

Physical Sciences (Chemistry and Physics), Grades 6–8

Learning Standard	Ideas for Developing Investigations and Learning Experiences
Properties of Matter	
1. Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.	Determine the weight of a dense object in air and in water. Explain how the results are related to the different definitions of mass and weight.
2. Differentiate between volume and mass. Define density.	
3. Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.	Calculate the volumes of regular objects from linear measurements. Measure the volumes of the same objects by displacement of water. Use the metric system. Discuss the accuracy limits of these procedures and how these limits explain any observed differences between the calculated volumes and the measured volumes.
4. Explain and give examples of how mass is conserved in a closed system.	Melt, dissolve, and precipitate various substances to observe examples of the conservation of mass.
Elements, Compounds, and Mixtures	
5. Recognize that there are more than 100 elements that combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.	Demonstrate with atomic models (e.g., ball and stick) how atoms can combine in a large number of ways. Explain why the number of combinations is large, but still limited. Also use the models to demonstrate the conservation of mass in the modeled chemical reactions.
6. Differentiate between an atom (the smallest unit of an element that maintains the characteristics of that element) and a molecule (the smallest unit of a compound that maintains the characteristics of that compound).	Use atomic models (or Lego blocks, assigning colors to various atoms) to build molecules of water, sodium chloride, carbon dioxide, ammonia, etc.
7. Give basic examples of elements and compounds.	Heat sugar in a crucible with an inverted funnel over it. Observe carbon residue and water vapor in the funnel as evidence of the breakdown of components. Continue heating the carbon residue to show that carbon residue does not decompose. Safety note: sugar melts at a very high temperature and can cause serious burns.
8. Differentiate between mixtures and pure substances.	

Physical Sciences (Chemistry and Physics), Grades 6–8

Learning Standard	Ideas for Developing Investigations and Learning Experiences
Elements, Compounds, and Mixtures (cont.)	
9. Recognize that a substance (element or compound) has a melting point and a boiling point, both of which are independent of the amount of the sample.	
10. Differentiate between physical changes and chemical changes.	Demonstrate with molecular ball-and-stick models the physical change that converts liquid water into ice. Also demonstrate with molecular ball-and-stick models the chemical change that converts hydrogen peroxide into water and oxygen gas.
Motion of Objects	
11. Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.	
12. Graph and interpret distance vs. time graphs for constant speed.	
Forms of Energy	
13. Differentiate between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.	
Heat Energy	
14. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.	
15. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.	
16. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.	Place a thermometer in a ball of clay and place this in an insulated cup filled with hot water. Record the temperature every minute. Then remove the thermometer and ball of clay and place them in an insulated cup of cold water that contains a second thermometer. Observe and record the changes in temperature on both thermometers. Explain the observations in terms of heat flow, including direction of heat flow and why it stops.

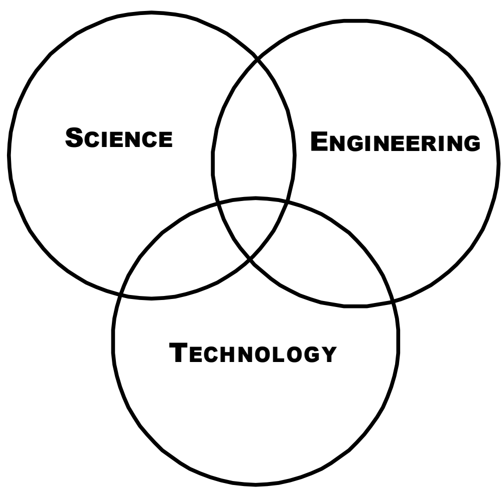
Technology/Engineering

Technology/engineering works in conjunction with science to expand our capacity to understand the world. Science investigates the natural world. The goal of engineering is to solve practical problems through the development or use of technologies, based on the scientific knowledge gained through investigation.

For example, the planning, design, and construction of the Central Artery Tunnel project in Boston (the ñBig Digò) was a complex and technologically challenging project that drew on knowledge of earth science and physics, as well as on construction and transportation technologies. Scientists and engineers apply scientific knowledge of light to develop lasers, fiber optic technologies, and other technologies in medical imaging. They also apply this scientific knowledge to develop such modern communications technologies as telephones, fax machines, and electronic mail.

The Relationships Among Science, Engineering, and Technology

Science seeks to understand the natural world, and often needs new tools to help discover the answers.



Engineers use scientific discoveries to design products and processes that meet societyõs needs.

Technologies (products and processes) are the result of engineered designs. They are created by technicians to solve societal needs and wants.

Although the term *technology* is often used by itself to describe the educational application of computers in a classroom, computers and instructional tools that use computers are only a few of the many technological innovations in use today. The focus of this Technology/Engineering strand is on applied technologies such as engineering design, construction, and transportation, not on instructional technology such as computer applications for classrooms.

Technologies developed through engineering include the systems that provide our houses with water and heat; roads, bridges, tunnels, and the cars that we drive; airplanes and spacecraft; cellular phones, televisions, and computers; many of todayõs toys; and systems that create special effects in movies. Each of these came about as the result of recognizing a need or problem and creating a technological solution using the engineering design process, as illustrated in the figure on page 84. Beginning in the early grades and continuing through high school, students carry out this design process in ever more sophisticated ways. As they gain more experience and knowledge, they are able to draw on other disciplines, especially mathematics and science, to understand and solve problems.

- In **grades 6–8**, students pursue engineering questions and technological solutions that emphasize research and problem solving. They identify and understand the five elements of a technology system (goal, inputs, processes, outputs, and feedback). They acquire basic safety skills in the use of hand tools, power tools, and machines. They explore engineering design; materials, tools, and machines; and communication, manufacturing, construction, transportation, and bioengineering technologies. Starting in grades 6ï 8 and extending through grade 10, the topics of power and energy are incorporated into the study of most areas of technology. Grades 6ï 8 students use knowledge acquired in their mathematics and science curricula to understand engineering. They achieve a more advanced level of skill in engineering design by learning to conceptualize a problem, design prototypes in three dimensions, and use hand and power tools to construct their prototypes, test their prototypes, and make modifications as necessary. The culmination of the engineering design experience is the development and delivery of an engineering presentation. Because of the hands-on, active nature of the technology/engineering environment, it is strongly recommended that it be taught by teachers who are certified in technology education, and who are very familiar with the safe use of tools and machines.

  Learning standards for grades 6ï 8 fall under the following seven subtopics: *Materials, Tools, and Machines; Engineering Design; Communication Technologies; Manufacturing Technologies; Construction Technologies; Transportation Technologies;* and *Bioengineering Technologies.*

Technology/Engineering, Grades 6–8

Please note: The number(s) in parentheses following each suggested learning activity refer to the related grades 6ï 8 Technology/Engineering learning standard(s).

LEARNING STANDARDS	SUGGESTED LEARNING ACTIVITIES
1. Materials, Tools, and Machines *Central Concept*: Appropriate materials, tools, and machines enable us to solve problems, invent, and construct.	
1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility). **1.2 Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.** **1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.**	Å Conduct tests for strength, hardness, and flexibility of various materials (e.g., wood, paper, plastic, ceramics, metals). (1.1) Å Design and build a catapult that will toss a marshmallow. (1.1, 1.2, 1.3) Å Use a variety of hand tools and machines to change materials into new forms through the external processes of forming, separating, and combining, and through processes that cause internal change(s) to occur. (1.2)
2. Engineering Design *Central Concept*: Engineering design is an iterative process that involves modeling and optimizing to develop technological solutions to problems within given constraints.	
2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign. **2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.** **2.3 Describe and explain the purpose of a given prototype.** **2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.** **2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.** **2.6 Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback.**	Å Given a prototype, design a test to evaluate whether it meets the design specifications. (2.1) Å Using test results, modify the prototype to optimize the solution (i.e., bring the design closer to meeting the design constraints). (2.1) Å Communicate the results of an engineering design through a coherent written, oral, or visual presentation. (2.1) Å Develop plans, including drawings with measurements and details of construction, and construct a model of the solution to a problem, exhibiting a degree of craftsmanship. (2.2)

Technology/Engineering, Grades 6–8

LEARNING STANDARDS	SUGGESTED LEARNING ACTIVITIES
3. Communication Technologies *Central Concept*: Ideas can be communicated though engineering drawings, written reports, and pictures.	
3.1 Identify and explain the components of a communication system, i.e., source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. **3.2 Identify and explain the appropriate tools, machines, and electronic devices (e.g., drawing tools, computer-aided design, and cameras) used to produce and/or reproduce design solutions (e.g., engineering drawings, prototypes, and reports).** **3.3 Identify and compare communication technologies and systems, i.e., audio, visual, printed, and mass communication.** **3.4 Identify and explain how symbols and icons (e.g., international symbols and graphics) are used to communicate a message.**	
4. Manufacturing Technologies *Central Concept*: Manufacturing is the process of converting raw materials (primary process) into physical goods (secondary process), involving multiple industrial processes (e.g., assembly, multiple stages of production, quality control).	
4.1 Describe and explain the manufacturing systems of custom and mass production. **4.2 Explain and give examples of the impacts of interchangeable parts, components of mass-produced products, and the use of automation, e.g., robotics.** **4.3 Describe a manufacturing organization, e.g., corporate structure, research and development, production, marketing, quality control, distribution.** **4.4 Explain basic processes in manufacturing systems, e.g., cutting, shaping, assembling, joining, finishing, quality control, and safety.**	
5. Construction Technologies *Central Concept*: Construction technology involves building structures in order to contain, shelter, manufacture, transport, communicate, and provide recreation.	
5.1 Describe and explain parts of a structure, e.g., foundation, flooring, decking, wall, roofing systems. **5.2 Identify and describe three major types of bridges (e.g., arch, beam, and suspension) and their appropriate uses (e.g., site, span, resources, and load).**	Design and construct a bridge following specified design criteria (e.g., size, materials used). Test the design for durability and structural stability. (5.3)

Technology/Engineering, Grades 6–8

LEARNING STANDARDS	SUGGESTED LEARNING ACTIVITIES
5. Construction Technologies (cont.)	
5.3 Explain how the forces of tension, compression, torsion, bending, and shear affect the performance of bridges. **5.4 Describe and explain the effects of loads and structural shapes on bridges.**	
6. Transportation Technologies *Central Concept*: Transportation technologies are systems and devices that move goods and people from one place to another across or through land, air, water, or space.	
6.1 Identify and compare examples of transportation systems and devices that operate on or in each of the following: land, air, water, and space. **6.2 Given a transportation problem, explain a possible solution using the universal systems model.** **6.3 Identify and describe three subsystems of a transportation vehicle or device, i.e., structural, propulsion, guidance, suspension, control, and support.** **6.4 Identify and explain lift, drag, friction, thrust, and gravity in a vehicle or device, e.g., cars, boats, airplanes, rockets.**	Å Design a model vehicle (with a safety belt restraint system and crush zones to absorb impact) to carry a raw egg as a passenger. (6.1) Å Design and construct a magnetic levitation vehicle (e.g., as used in the monorail system). Discuss the vehicleôs benefits and trade-offs. (6.2) Å Conduct a group discussion of the major technologies in transportation. Divide the class into small groups and discuss how the major technologies might affect future design of a transportation mode. After the group discussions, ask the students to draw a design of a future transportation mode (car, bus, train, plane, etc.). Have the students present their vehicle designs to the class, including discussion of the subsystems used. (6.1, 6.3)
7. Bioengineering Technologies *Central Concept*: Bioengineering technologies explore the production of mechanical devices, products, biological substances, and organisms to improve health and/or contribute improvements to our daily lives.	
7.1 Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces. **7.2 Describe and explain adaptive and assistive bioengineered products, e.g., food, bio-fuels, irradiation, integrated pest management.**	Brainstorm and evaluate alternative ideas for an adaptive device that will make life easier for a person with a disability, such as a device that picks up objects from the floor. (7.1)

WHAT IT LOOKS LIKE IN THE CLASSROOM

Local Wonders

Adapted from the *Building Big Activity Guide*, pp. 36ï 37 (www.pbs.org/wgbh/buildingbig)

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After building newspaper towers and talking about structures and foundations, sixth-graders at the Watertown, Massachusetts Boys and Girls Club brainstormed a list of interesting structures in their town. They selected St. Patrickõs, an elaborate church across the street from the clubhouse, as the focus for an investigation about a ñLocal Wonder.ò

The students began their investigation by brainstorming questions about their Local Wonder. Questions that focused on engineering included the following:

Å When was it built?
Å What is it made of?
Å Why did the builders choose that material?
Å What is underneath the building?
Å What holds it up?
Å What keeps it from falling down?
Å How was it built?
Å Were there any problems during construction and how were they solved?

Questions with a social/environmental focus included the following:

Å Why was it built?
Å Who built it?
Å What did the area look like before it was built?

Next, the students participated in hands-on activities that explored basic engineering principles such as force, compression, tension, shape, and torsion. They toured the church, took photographs, researched the structure, interviewed long-time community members about their memories about the structure, and interviewed engineers, architects, and contractors who worked on the construction project. They conducted research at the library, the Historical Society, and the Watertown Building Inspectorõs office, where they acquired the buildingõs plans and copies of various permits. They used this information to develop a timeline of the buildingõs history.

Students used the following method to estimate the size of the church: First, they selected one student, Josh, and measured his height. Then Josh stood next to the church, while the rest of the club members stood across the street. The teacher asked each student to close one eye and use his or her fingers to ñstackò Joshõs height up to the top of the church. The each student multiplied the number of times he or she stacked Joshõs height, to find the total estimated height of the church.

Small groups of students met and prepared final reports, using the following generic outline: I
Name of group submitting report
II Name and description of structure (identify the type of structure, such as a bridge or skyscraper, and describe and explain its parts)
III Location of structure
IV Approximate date structure was completed
V Approximate size of structure
VI Why we chose this particular Local Wonder
VII Whatõs important about our Local Wonder

VIII Things we learned about our Local Wonder (include information such as type of construction, engineering design concepts, and forces acting on the structure)
IX Interesting facts about our Local Wonder

Your community may not have an Eiffel Tower or a Hoover Dam, but for your Local Wonder you can choose any structure in your community that is significant because of its appearance, uniqueness, or historical or social impact. Consider local bridges, tunnels, skyscrapers or other buildings, domes, dams, and other constructions. You can e-mail the American Society of Civil Engineers at buildingbig@asce.org to connect with a volunteer civil engineer for this activity. To help select your Local Wonder, have the class brainstorm a list or collect some photographs for discussion.

Any group that completes this project can submit its investigation to pbs.org/buildingbig. Send them your complete report, including photographs or original drawings of your local wonder. Students should be encouraged to draw the structure from a variety of different perspectives. Students can also share their reports with other classes in their school or at a local town meeting.

Assessment Strategies

Å Share examples of other previous groupsô completed investigations with your students at the beginning of the project. Discuss and develop criteria for effective reports, and identify what constitutes quality work.

Å Students can record their learning in an engineering journal. Students can write down each day what they have learned, questions that they may have, resources they found helpful, and resources they need to consult. The teacher should read the journals to monitor studentsô progress and levels of participation, and to identify what topics the students have mastered and which areas of learning need to be reinforced by additional instruction.

Å Post your Local Wonder report on your school district website, on the town website, or on a town agencyôs website (e.g., the Chamber of Commerce). Include an e-mail address and encourage feedback.

Å At the end of the unit, provide the students with a photograph of a similar structure from another town or area. Ask them to write a final paper that compares this structure to their own Local Wonder. How are they alike? Different? Compare the materials, designs, and purposes of these structures.

Engineering Design Learning Standards

Grades 6–8

2.2 Demonstrate methods of representing solutions to a design problem (e.g., sketches, orthographic projections, multi-view drawings).

2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.

Construction Technologies Learning Standards (Applicable standards may depend on structure selected.)

Grades 6–8

5.1 Describe and explain parts of a structure (e.g., foundation, flooring, decking, wall, roofing systems).

5.2 Identify and describe three major types of bridges (i.e., arch, beam, and suspension) and their appropriate uses (e.g., based on site, span, resources, and load).

5.3 Explain how the forces of tension, compression, torsion, bending, and shear affect the performance of bridges.

5.4 Describe and explain the effects of load and structural shape on bridges.

Appendix B

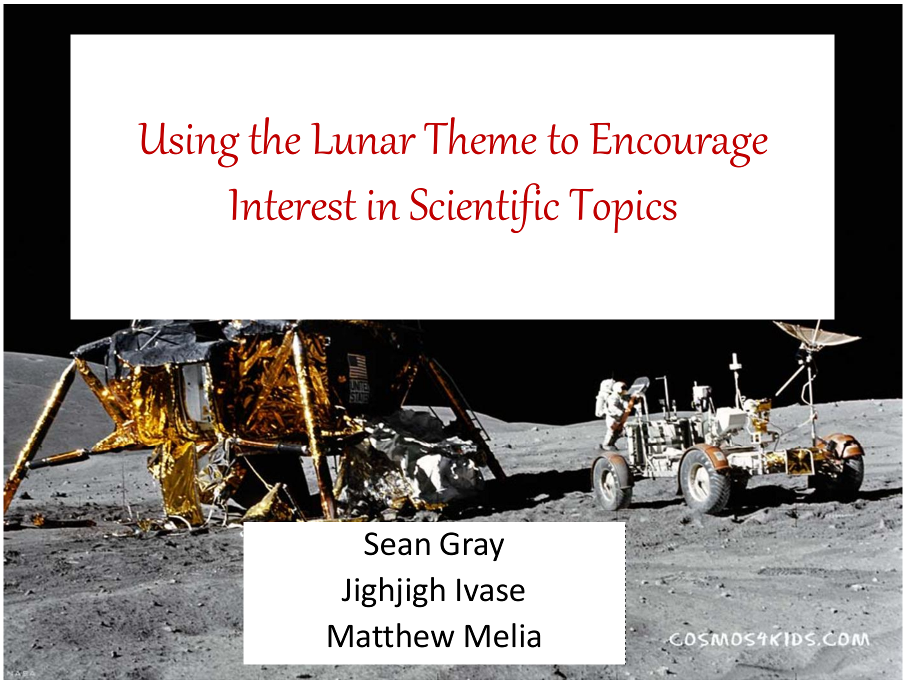

Figure 1- http://www.cosmos4kids.com/

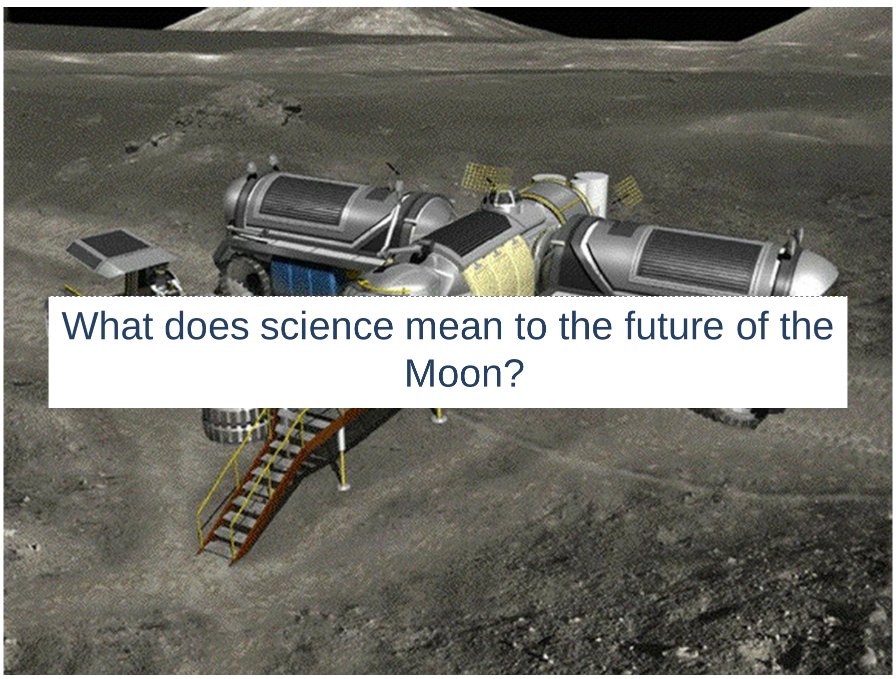

Figure 2- http://aboutfacts.net/

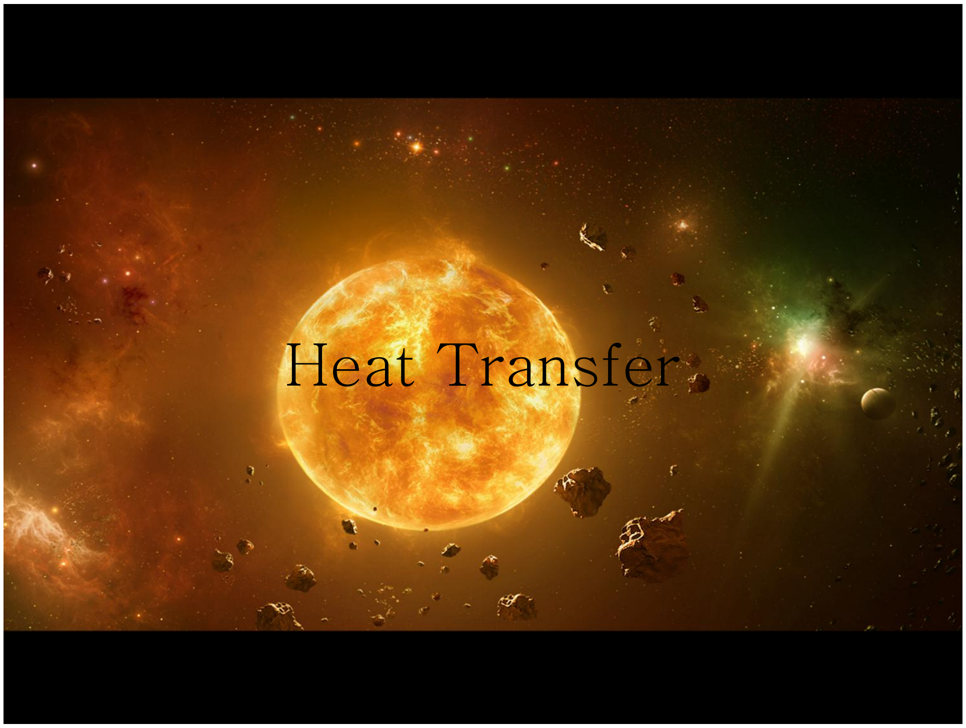

Figure 3- http://fc02.deviantart.net/

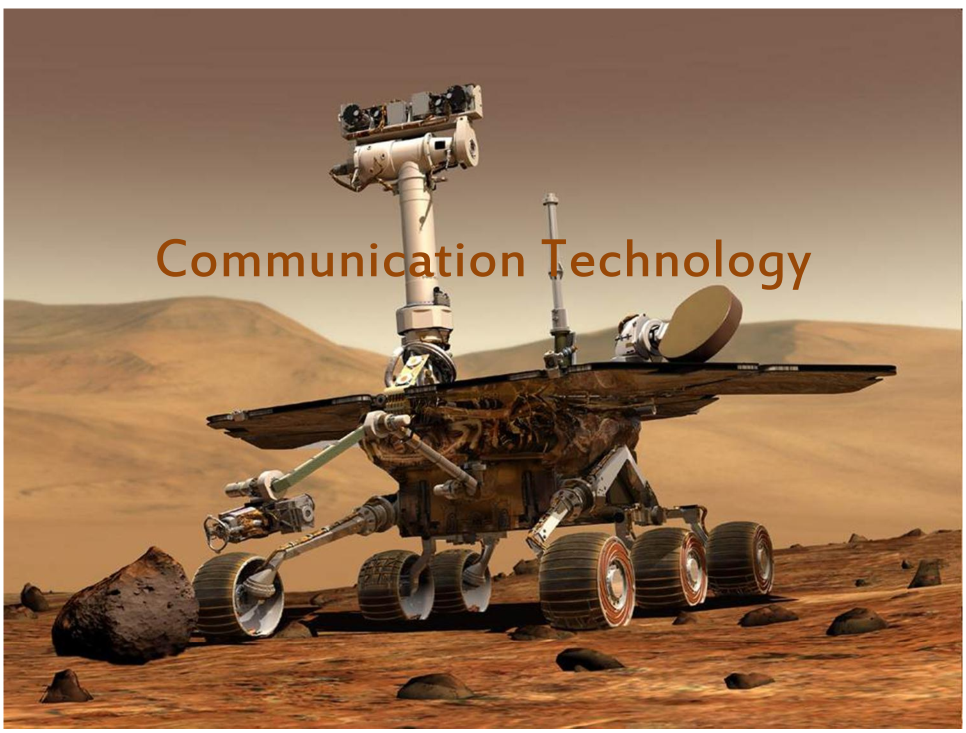

Figure 4- http://sciencedude.ocregister.com/

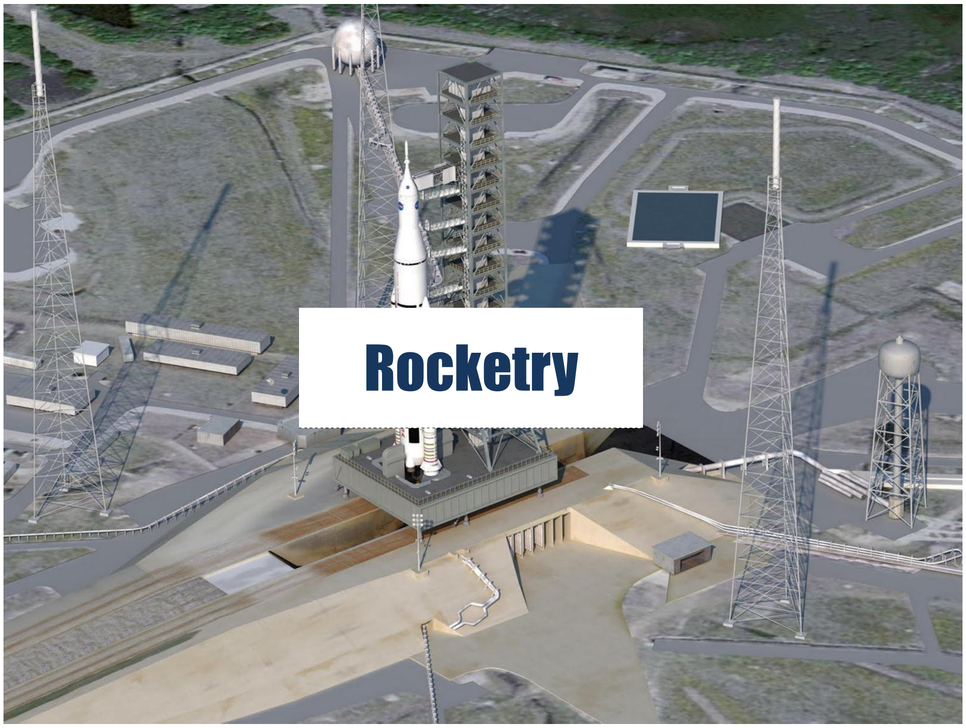

Figure 5- http://4.bp.blogspot.com/

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